Commissioning and first efficiency measurements of the cryogenic gas stopping Cell at SHIPTRAP

Christian Droese

Ernst-Moritz-Arndt-Universität Greifswald

Motivation

Direct mass measurements are an important tool to

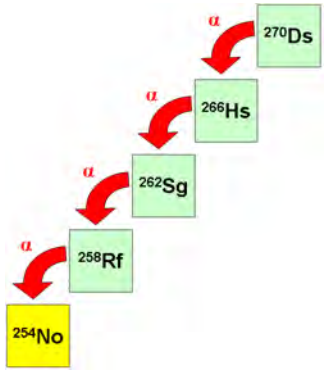
- to obtain absolute nuclear binding energies

$$M(Z,N) = ZM_p + NM_n - B(N,Z)$$

- to gain informations about the nuclear shell structure

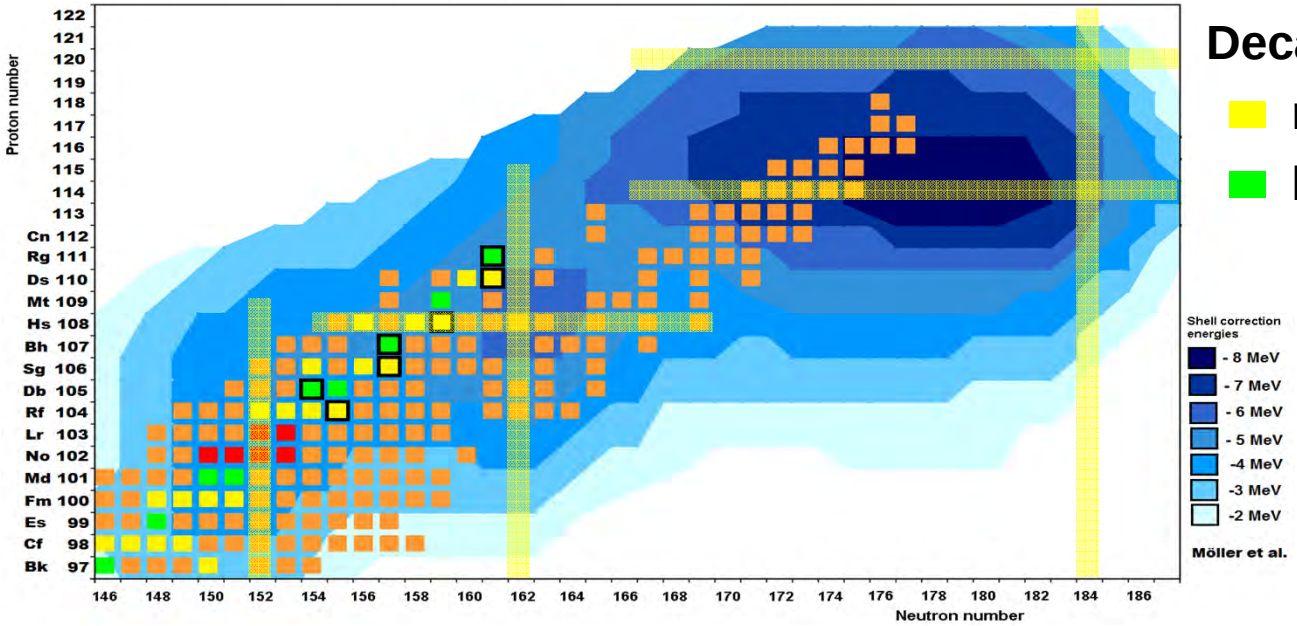
- to benchmark nuclear models

- to obtain anchor points to fix alpha-decay chains



Motivation

Up to now the masses of $^{252\text{-}255}$No[1] and $^{255\text{-}256}$Lr[2] were directly measured at the Penning-trap mass spectrometer SHIPTRAP



Decay chains linked to :

- **nobelium isotopes**
- **lawrencium isotopes**

^{256}Lr: reaction cross section = 60nb

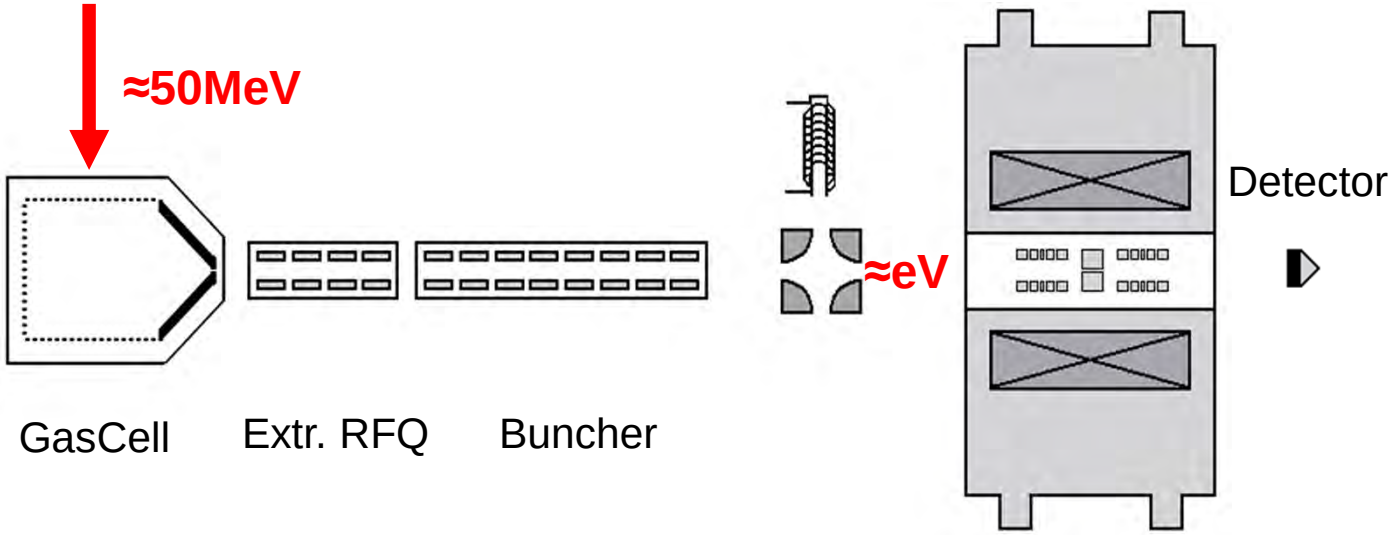
→ Mass determination with 50 ions took 4 days

→ **Measurement of superheavy elements envisaged (next ^{257}Rf = 15nb)**

[1] M. Block et al., Nature 463 (2010) 785
[2] E. Minaya Ramirez et al., Science 337 (2012) 1207

SHIPTRAP Experimental Setup

Reaction products from SHIP



Overall efficiency approximately ≈ 2%

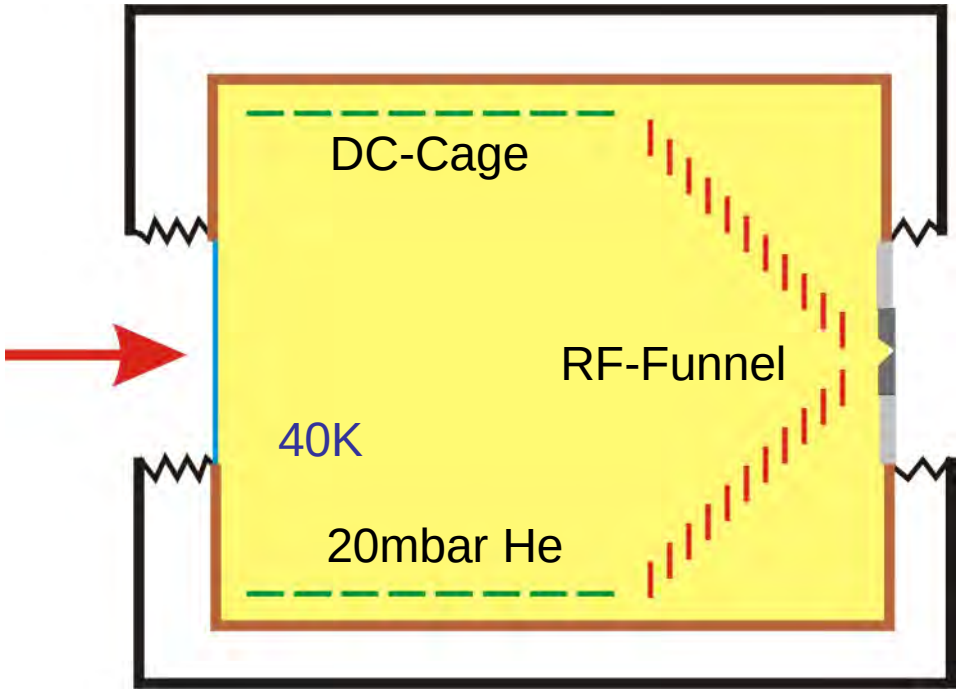
Bottleneck : gas stopping cell (stopping+extraction efficiency ≈ 10%)[1]
(stopping efficiency ≈ 40%)

→ **Setup of a second generation gas stopping cell with a higher efficiency**

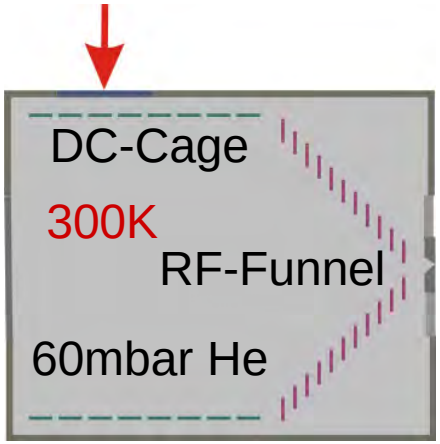
[1] J. B. Neumayr et al., Nucl. Instr. And Meth. B 244 (2006) 489

CryoCell Setup

Cryo Cell



Gas Cell



Advantages compared to 1st generation gas cell:

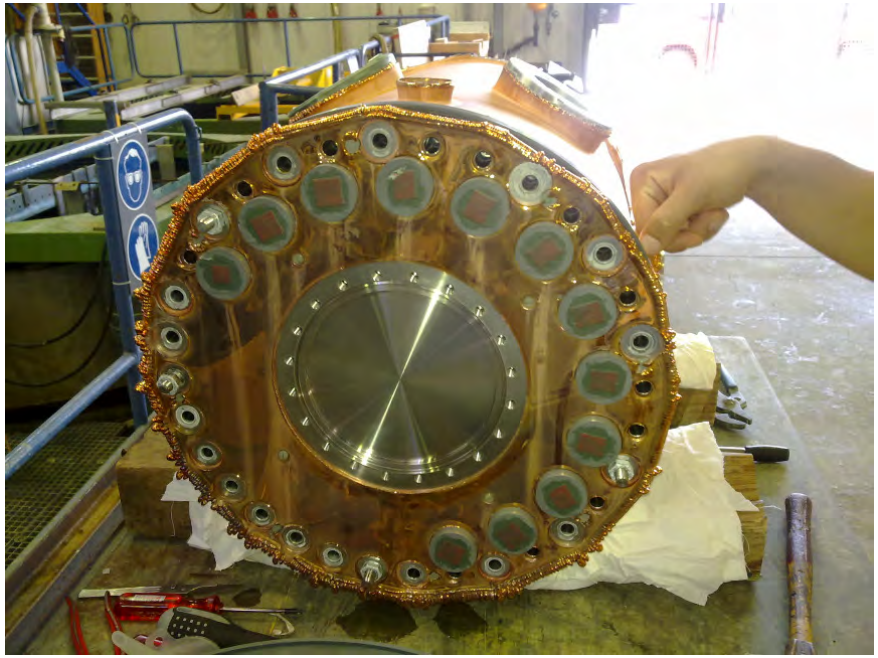
- -Larger stopping volume
- -Coaxial injection of reaction products
- -Higher cleanliness
- -Larger gas density at a smaller absolute pressure

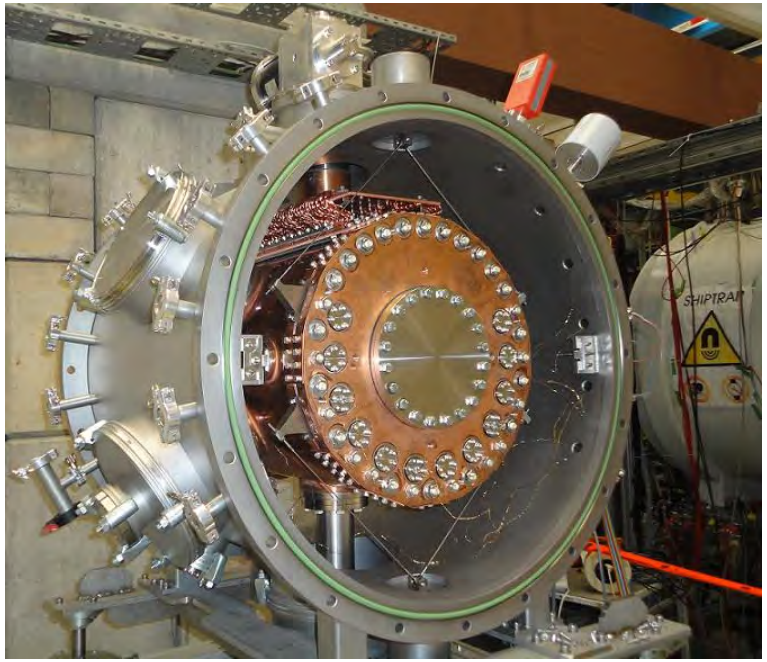
→ **Efficiency Boost from 10% to 35%[1]**

[1] S. Eliseev et al., Nucl. Instr. Meth. B 266 (2008) 4475

Inner and outer chamber

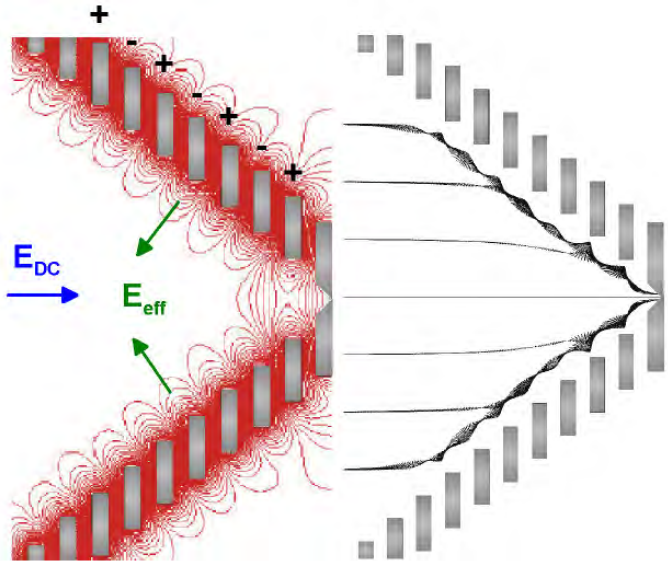
Inner chamber: - copper plated with a 2mm layer
- cooled with 20K single-stage cryo cooler (100W at 77K)
- fixed with 12 stainless steel rods of 1.6mm thickness to outer chamber
- wrapped in multilayer insulation foil





RF-Funnel

- 76 ring electrodes
- Diameter: from 266mm down to 5mm
- Total capacity of 2.6nF
- 1mm distance between electrodes (0.5mm at last 20 segments)



RF with 180° phase shift between neighboring electrodes superimposed with DC gradient

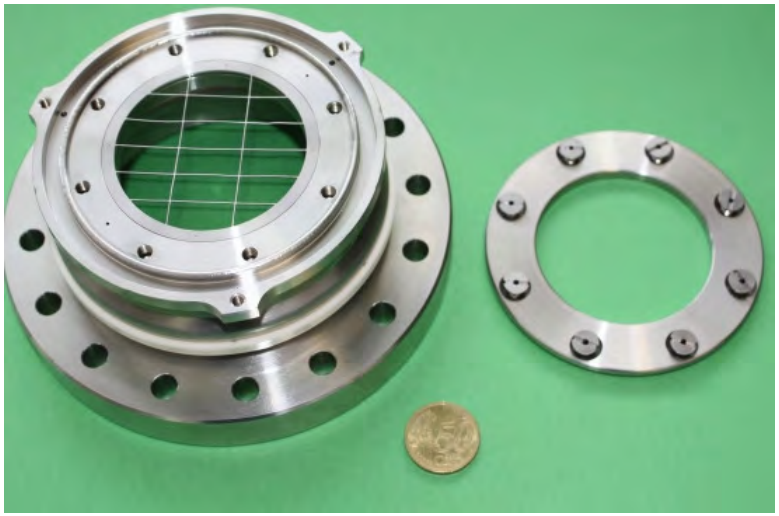
Tested in UHV and 50mbar He at 300K and 45K:

f_{res}=1017kHz
$U_{out,pp}$=320V

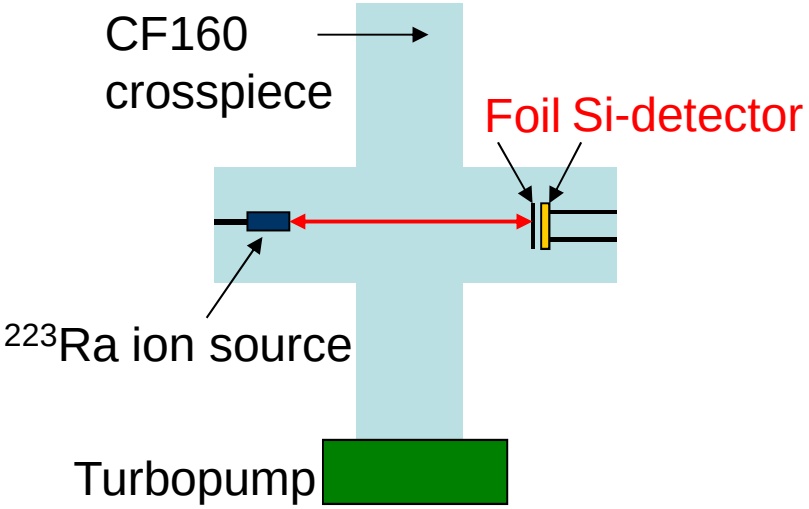
DC-Cage and Entrance Window

- 8 ring segments with a DC gradient of >10V/cm
- Diameter of 260mm
- Extraction Time ≈ ms

- beam diameter behind SHIP of 60mm
- electrical insulated
  -> increase homogenity of DC potential
- currently 3µm Ti foil + gold sealing
- 90% energy loss of reaction products

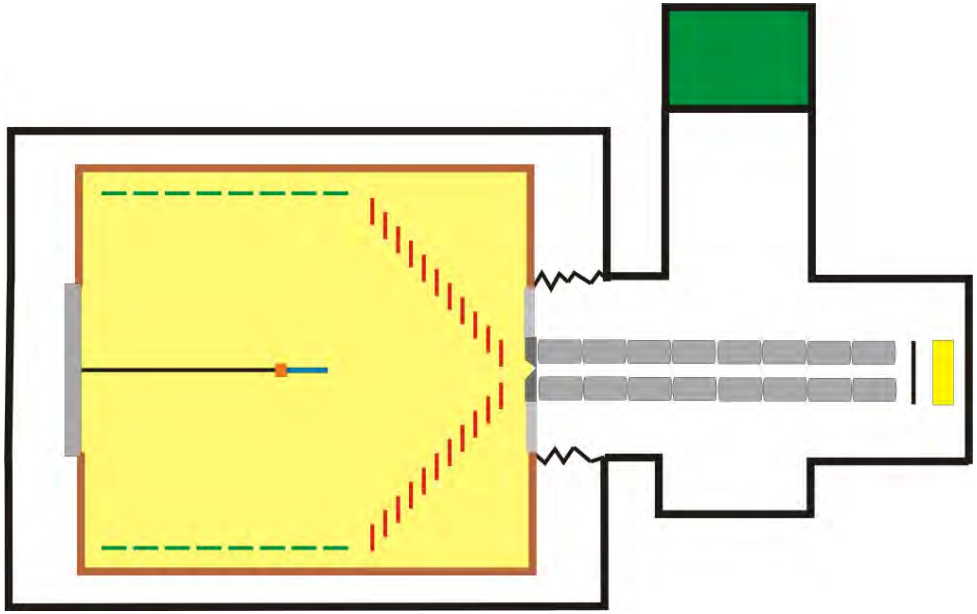


Efficiency measurement setup



Test chamber

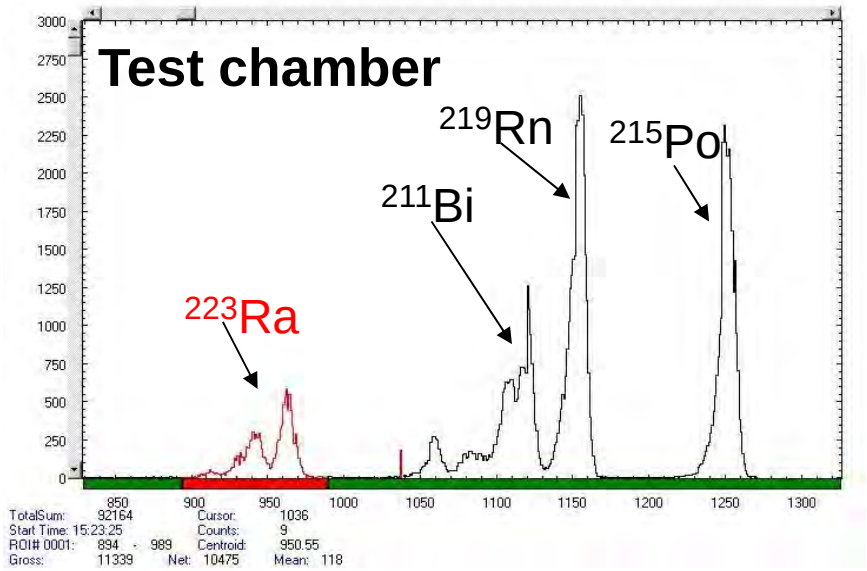
- determine initial acitivity via determination of number of ^{223}Ra decays

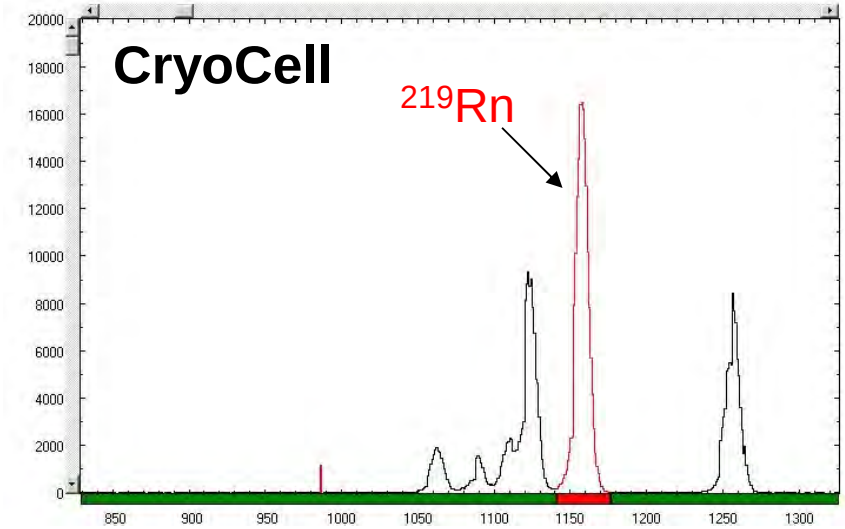


CryoCell

- Same foil-/detector-arrangement installed (same DAQ electronics)
- Extraction RFQ installed
- placed ^{223}Ra source inside the inner chamber
- determine number of ^{219}Rn decays

Offline efficiency determination





Efficiency determination

- count number of ^{223}Ra decays and take the ratio between the spherical angle and detector surface into account
- take half-life of the ^{223}Ra into account (11.43days)
- count number of ^{219}Rn decays behind CryoCell and take the ratio between foil surface and detector suface detector surface into account

→ **Preliminary efficiency: 75%**

Summary and Outlook

- Cryogenic gas stopping cell will lead the way to mass measurements of SHE
- All major parts tested separately -> working
- first extraction tests successfully performed
  preliminary efficiency = 75%
- further offline tests with ^{223}Ra will be performed
- Final efficiency needs to be determined in an online experiment
  -> Ready for beamtime!!!

Thank you for your attention

M. Block, K. Blaum, C. Droese, M. Dworschak, S. Eliseev, F. Herfurth, M. Laatiaoui, E. Minaya Ramirez, P. Thirolf

TECHNISCHE
UNIVERSITÄT
DARMSTADT